A Scaling Law for Accretion Zone Sizes

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Current theories of runaway planetary accretion require small random velocities of the accreted particles. Two body gravitational accretion cross sections, which ignore the tidal perturbations of the Sun, are not valid for the slow encounters which occur at low relative velocities. Wetherill and Cox (*Icarus* **63**, 290, 1985) have studied accretion cross sections for rocky protoplanets orbiting at 1 AU. Using analytic methods based on Hill's lunar theory (Petit and Henon, *Icarus* **66**, 536, 1986) one can scale these results for protoplanets that occupy the same fraction of their Hill sphere as does a rocky body at 1AU. Generalization to bodies of different sizes is achieved here by numerical integrations of the three body problem. Starting from initial positions far from the accreting body, test particles are allowed to encounter the body once and the cross section is computed. A power law is found relating the cross section to the radius of the accreting body (of fixed mass). The value of the exponent varies with the initial distribution of inclinations of the test particles. It is found that for an initial distribution of planar circular orbits, with uniform semi-major axes spacing, the cross section obeys an $r^{\frac{1}{2}}$ power law. For nonplanar circular-orbit distributions, and fixed small inclination, the cross sections behave approximately as r. Variable non-zero inclination distributions result in intermediate power law dependences. These power laws are valid for the range of parameters of interest to runaway accretion theories of the planets, but different results apply in satellite systems near Roche's limit.